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# Effect of phosphorous and sulphur fertilization on vegetative growth of fenugreek (*Trigonella foenum-graecum L.*)

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## Abstract

An experiment was carried out at the research field of Sher-e-Bangla Agricultural University, Dhaka, during the period from November 2016 to march 2017 to investigate the effect of four levels of phosphorous viz., 0, 20, 30, 40 kg P $ha^{-1}$ and three levels of sulphur viz., 0, 10 and 20 kg S $ha^{-1}$ on vegetative growth of fenugreek (cv. BARI Methi-1). The highest plant height (26.73 cm) was found from the application of 40 kg P $ha^{-1}$ and 10 kg S $ha^{-1}$ at 30 days after sowing (DAS), whereas the maximum plant height (32.47 cm) was found with the dose of 40 kg P $ha^{-1}$ and 20 kg S $ha^{-1}$ at 60 DAS. The maximum number of primary branches $plant^{-1}$ (4.60 at 30 DAS and 5.73 at 60 DAS) was obtained from the application of 40 kg P $ha^{-1}$ and 20 kg S $ha^{-1}$. The above mentioned doses help to obtain maximum seed yield. Therefore, application of P-S (40+10) kg $ha^{-1}$ with a blanket dose of N-K (80+67) kg $ha^{-1}$ + 5.0 tons cowdung might be considered as suitable fertilizer dose for production of fenugreek.

***Keywords:*** Fertilization; Sulphur; Vegetative Growth; Fenugreek



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## 1. Introduction

Fenugreek (*Trigonella foenum-graecum* L.) locally known as 'methi' belonging to the family Leguminosae and sub family Papilionaceae is widely used as spice and condiment to add flavor in various foods. It was also named, *Trigonella*, from Latin language that means "little triangle" due to its yellowish-white triangular flowers (Flammang et al., 2004). It is named as *Methi* (Hindi, Urdu, Punjabi and Marathi), *Hulba* (Arabic), *Moshoseitaro* (Greek), *Uluva* (Malayalam), *Shoot* (Hebrew), *Dari* (Persian) and Heyseed in English. Fenugreek (*Trigonella foenum-graecum* L.) is one of the oldest medicinal plants originated in central Asia ~4000 BC (Altuntas et al., 2005). Its description and benefits had been reported in the *Ebers Papyrus* (one of the oldest maintained medicinal document) earlier in 1500 BC in Egypt (Betty, 2008). It is being commercially grown in India, Pakistan, Afghanistan, Iran, Nepal, Egypt, France, Spain, Turkey, Morocco, North Africa, Middle East and Argentina (Flammang et al., 2004; Altuntas et al., 2005).

Fenugreek (*Trigonella foenum - graecum* L.) is herbaceous annual whose seeds contain proteins (25-36% of the dry weight of the plant) and a range of vitamins (Mehrafarin et al., 2011). Its seeds also contain different amounts of nutrients, most important like iron, calcium, phosphorus, potassium and other mineral elements (Ali et al., 2012).

Though it have exceptional nutritional and medicinal values, only a few studies have been done for its genetic enhancements and development the production of fenugreek.

Fenugreek *(Trigonella foenum-graecum* L.*)* has a long history of medicinal uses in Ayurveda. It is well-known as traditional medicine for diabetes, indigestion, elevation of lipids and edema (fluid retention) of the legs. Fenugreek is also good source of dietary protein for human and animals. Fenugreek is a good soil renovator and is widely used as a green manure (Abdelgani et al., 1999). It is used as a vegetable, spice and a medicinal plant. Since antioxidant properties have been linked to health benefits of natural products, such properties were studied in germinated fenugreek seeds which are considered to be more beneficial than dried seeds (Dixit et al., 2005).

These plants are used for blood lipids and sugar decreasing in diabetic and non-diabetic peoples and have antioxidant and antibacterial activity. This plant decreases body fats and is effective on obesity. This plant is used in therapy atherosclerosis (Nandini et al., 2007), rheumatism (Vyas et al., 2010), sugar lowering (Gupta et al., 2001), blood lipids lowering (Xue et al., 2007), appetizer (Max, 1992) and contain antioxidant activity (Birjees et al., 2008).

Phosphorus is essential for the general health of the plant and root development and more stem strength. It improves flower formation and makes seed production more uniform. It also improves seed quality and resistant to plant disease. Plant growth and seed yield was increased in fenugreek when phosphorus was applied @ 26 kg P (60 kg $P_2O_5$) $ha^{-1}$ (Bhairagi, 2014; Purbey and Sen, 2005). Sharma et al. (2014) obtained maximum number of primary branches $plant^{-1}$, pods $plant^{-1}$, seeds $pod^{-1}$, seed yield from 17.6 kg P (40 kg $P_2O_5$) $ha^{-1}$. It is also reported that an increase in seed yield of fenugreek was obtained with phosphorous doses of 40 and 60 kg $ha^{-1}$ (Khiriya et al., 2001; Khiriya et al., 2003 and sheoran et al., 1999).

Sulphur is one of the major plant nutrients for increasing yield of the crop. Sulphur plays a vital role in plant metabolism. It constitutes the main element of amino acids such as cysteine and methionine, which are of essential nutrients. Sulphur has positive effects on the root growth in plants (Kacar, 1984). Lal et al. (2015) reported that application 30 kg S $ha^{-1}$ produced the highest number of primary branches $plant^{-1}$ and number of pods $plant^{-1}$ with maximum seed yield of fenugreek. Gordara et al. (2013) obtained the highest seed yield of fenugreek from the application of 45 kg S $ha^{-1}$ which was statistically similar to 30 kg S $ha^{-1}$; whereas Nehara et al. (2006) got the highest seed yield from 25 kg S $ha^{-1}$. Therefore, it is clear that seed yield of fenugreek can be increased by judicious application of phosphorous and sulphur fertilization. But the information on fenugreek research regarding phosphorous and sulphur fertilization is not available in Bangladesh.

Keeping the above facts in view the present experiment was undertaken with following objectives:

I. To investigate the combined effect of phosphorous and sulphur on vegetative growth of fenugreek.
II. To observe the influence of phosphorous and sulphur on seed yield attributes of fenugreek.
III. To find out the suitable combination of phosphorous and sulphur for higher seed yield of fenugreek.

## 2. Review of literature

Very few works have been done for the improvement of fenugreek in Bangladesh. However, a considerable number of investigations were done under the agro-climatic situations of Indian subcontinent and elsewhere in the world. Among them Jasim et al. (2016) studied the effect of 5 soil fertilization treatments on growth and yield of fenugreek and found that chemical fertilizer was superior significantly compared to other treatment in plant height, number of leaves, leaf area and wet and dry weight, while urea spray was superior in plant height, leaves no. and soft weight.

Many studies stated the influence of nitrogen and phosphorus applications on fenugreek, however, there are hardly any reports available on the effects of potassium treatments which presents and discusses these aspects of fenugreek as influenced by potassium treatments.

Ramkishor et al. (2015) examined the effect of clay mixing, irrigation and sulphur on growth and yield of fenugreek on loamy sand soil, during *rabi* seasons 2006-07 and 2007-08 and found that the application of sulphur @ 40 kg/ha gave significantly higher the growth, yield attributes and yield in pooled mean basis over rest of treatments. Lal et al. (2015) studied the growth and yield of fenugreek as influenced by different levels of sulphur and zinc nutrients. Non-significant influence with respect to reduction in days to seed germination and days of flowering were observed due to higher dose of sulphur. Similarly plant height at different growth stages after sowing was not significantly influenced with varying levels of sulphur. Number of primary and secondary branches, number of pods and seed yield was affected significantly with different levels of sulphur. Verma et al. (2013) conducted an experiment during *rabi* season of 2011-2012 to study the effect of vermicompost and sulphur on growth, yield and nutrient uptake of fenugreek and found that

application of sulphur up to 40 kg $ha^{-1}$ resulted in significantly higher plant height and branches/plant at 60, 90 DAS. Metha et al. (2012) examined the effects of nitrogen, phosphorus and bio-fertilizers on fenugreek with 16 treatment combinations in factorial RBD with three replications and found that application of 20 kg N and 40 kg $P_2O_5$ $ha^{-1}$ gave significantly higher plant height at all the growth stages, and seed, straw and biological yields as well as protein content in seed and straw over 10 kg N and 20 kg $P_2O_5$ $ha^{-1}$, respectively. Jagdale and Dalve (2010) lead an experiment on fenugreek with five levels of nitrogen *i.e.* 0, 30, 60, 90 and 120 kg $ha^{-1}$ and five levels of phosphorus *i.e.* 0, 15, 30, 45 and 60 kg $ha^{-1}$. They found that the vegetative growth in terms of plant height, number of leaves and number of branches was increased due to an application of 120 kg nitrogen and 60 kg phosphorus per ha. Nehara et al. (2006) examined the response of fenugreek (*Trigonella foenum-graecum* L.) under different levels of phosphours (0, 25 and 50 kg $P_2O_5$ $ha^{-1}$), sulphur (0, 25 and 50 kg S $ha^{-1}$) and plant-growth regulators (control, Tricontanol 2 ppm, naphthaline acetic acid 20 ppm and etheophon 100 ppm). An increase in P level up to 50 kg $P_2O_5$ $ha^{-1}$ and sulphur up to 50 kg S $ha^{-1}$ significantly increased the yield-attributing characters; the seed, straw and biological yields; and the net returns of fenugreek. McCormick et al. (2001) compared growth, yield and nitrogen (N) inputs of fenugreek with field pea, faba bean, lentil, vetch and medic. Four fenugreek accessions flowered at a similar time to faba bean, but earlier than other species. Faba bean produced the highest grain yield. The relative N fixation efficiency was highest for faba bean, field pea and vetch (21-23 kg N/t). Jat and Shakwat (2001) conducted a research to examine the effect of sulfur application up to 100 kg $ha^{-1}$. Dual inoculation with *Rhizobium* + PSB significantly increased the seed and biological yields during both the years and straw yield during the first year. Phosphorus and sulphur applied to fenugreek significantly increased the grain, stover and biological yields of succeeding pearl millet.

## 3. Materials and methods

The experiment was conducted at Sher-e-Bangla Agricultural University farm, Dhaka, Bangladesh during the period from November 2016 to March 2017 to find out the optimum Phosphorous and Sulphur fertilization rate on yield attributes and yield of fenugreek. This chapter deals with a brief description on experimental site, climate, soil, land preparation, layout of the experimental design, intercultural operations, data recording and their analyses under the following headings and sub-headings.

### 3.1. Experimental site and soil

The experimental field is located at 23°41' N latitude and 90° 22' E longitude at height of 8.6m above the mean sea level. It belongs to the AEZ 28, Modhupur Tract (FAO, 1998).

### 3.2. Climate

The experimental field was situated under Sub-tropical climate; usually the rainfall is heavy during *kharif* season, (April to September) and short duration in *rabi* season (October to March). In *rabi* season

temperature is generally low and there is plenty of sunshine. The temperature tends to increase from February as the season proceeds towards *kharif*. The site where the experiment was conducted had subtropical climate and the *rabi* season extended from October to early March.

### 3.3. Seed

High yielding variety of fenugreek (cv. BARI Methi-1) developed by the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur was used as experimental material. The seed was collected from Regional Spices Research Centre, BARI, Joydebpur, Gazipur.

### 3.4. Treatments

Four levels of phosphorous and three levels of sulphur and their combinations were used in the experiment. These were:

Factor A: Four phosphorous levels

i. 0 kg $ha^{-1}$ ($P_0$)
ii. 20 kg $ha^{-1}$ ($P_1$)
iii. 30 kg $ha^{-1}$ ($P_2$)
iv. 40 kg $ha^{-1}$ ($P_3$)

Factor B: Three levels of sulfur

i. 0 kg $ha^{-1}$ ($S_0$)
ii. 10 kg $ha^{-1}$ ($S_1$)
iii. 20 kg $ha^{-1}$ ($S_2$)

A total of 12 treatment combinations:

| | | | |
|---|---|---|---|
| $P_0S_0$ | $P_1S_0$ | $P_2S_0$ | $P_3S_0$ |
| $P_0S_1$ | $P_1S_1$ | $P_2S_1$ | $P_3S_1$ |
| $P_0S_2$ | $P_1S_2$ | $P_2S_2$ | $P_3S_2$ |

### 3.5. Design and layout of the experiment

The experiment was laid out in randomized complete block design (RCBD) with 3 replications. The size of unit plot was 3 m x 1.2 m. The total number of treatments was 12 (4 levels of Phosphorous × 3 levels of Sulfur) and the number of plots were 36.

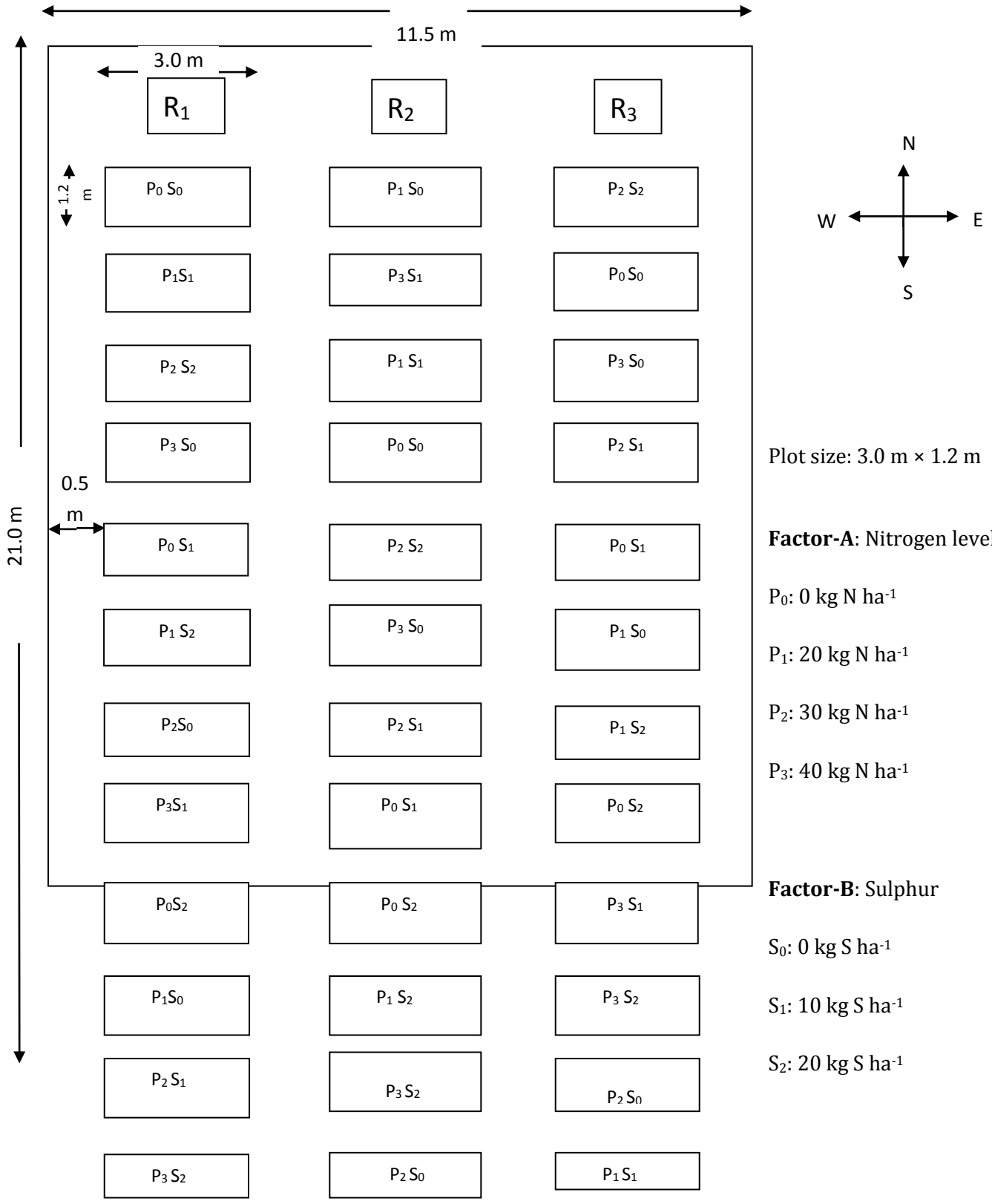


**Figure 1.** A field layout of the experiment having four levels of phosphorus and three levels of sulphur

## 3.6. Land preparation

The land was opened by disc plough 15 days before seeding. Thereafter, the land was prepared thoroughly by ploughing and cross ploughing followed by laddering and harrowing to have good tilth. Weeds and stubbles of the previous crops were collected and removed from the field during land preparation. Soil clods were broken and plots were prepared as 15 cm raised seed bed so that irrigation and rain water easily could drain out and seeds could easily be germinated.

## 3.7. Fertilizer application

Manures and fertilizers were applied at the following doses Anon. (2010).

| Nutrient/Fertilizer | Rate (Dose) | Fertilizer applied |
|---|---|---|
| Cowdung | 5 t $ha^{-1}$ | Well rotten cowdung |
| Nitrogen | 80 kg $ha^{-1}$ | Urea |
| Phosphorus | As per treatment | TSP |
| Potassium | Potassium 67 kg $ha^{-1}$ | MoP |
| Sulphur | As per treatment | Gypsum |

The entire amount of cowdung, phosphorus from TSP and potassium from MoP, sulphur from gypsum and one-half of nitrogen from urea were applied during final land preparation. The rest of the nitrogen was top dressed in two equal splits at 30 and 60 days after sowing.

## 3.8. Sowing

Fenugreek seeds were soaked in water for 6 hours to enhance germination. Seeds were also treated with Bavistin at the rate of 2 g per kg of seeds before sowing. The seeds were sown in rows 25 cm apart continuously by hand @ 15 kg/ha (Anon., 2010). To allow uniform sowing in rows seeds were mixed with some loose soil (about four to five times of weight of seeds). The seeds were covered with good pulverized soil just after sowing and gently pressed by hands. The sowing was done on November 25, 2016 with slight watering just to supply sufficient moisture needed for quick germination. Seedlings of the plots were thinned later to maintain 10 cm intra spacing (plant to plant distance) 25 days after sowing (DAS).

## 3.9. Intercultural operations

The desired population density was maintained by thinning plants 20 DAS. Irrigation, mulching, weeding and plant protection measures etc. were performed for better crop establishment and proper plant growth.

### *3.9.1. Weeding*

The field was kept free by hand weeding. First weeding was done after 2 days after sowing (DAS). Plant thinning was also done at the time of weeding. Second and third weeding was done after 35 and 50 DAS, respectively.

### *3.9.2. Irrigation*

For good germination water was given to the plots every two days by water cane with fine mashed nozzle till germination. Then three irrigations were given at 30, 60 and 90 days after sowing.

## 3.10. Harvesting

Seeds were harvested on 26 March, 2017 when pod color changed into yellowish brown in color (Anon., 2010). To avoid shattering of fruits, harvesting of seed plant was cut to the base by sickles in the early morning. Then the stalks with seeds were dried in the sun. Seeds (grains) were separated by beating with sticks and cleaned by winnowing and dried properly (10% moisture of seed).

## 3.11. Data collection

Ten (10) plants from each plot were selected randomly and were tagged for the data collection. Some data were collected from sowing to harvesting with 10 days interval and some data were collected at harvesting stage. The sample plants were uprooted prior to harvest and dried properly in the sun. The seed yield and straw yield per plot were recorded after cleaning and drying those properly in the sun. Data were collected on the following parameters:

1- Plant height (cm) at 30 and 60 days after sowing (DAS)
2- Number of primary branches plant$^{-1}$ at 30 and 60 DAS
3- Plant spread (cm) at first flowering
4- Number of pods plant$^{-1}$
5- Weight of seeds pod$^{-1}$ (mg)
6- 1000 seed weight (g)
7- Weight of single pod (g)
8- Weight seeds plant$^{-1}$ (g)
9- Number of seeds pod$^{-1}$
10- Weight of straw plot$^{-1}$ (g)
11- Number of plants plot$^{-1}$ at harvest
12- Seed yield plot$^{-1}$ (g)
13- Seed yield (kg ha$^{-1}$)

### *3.11.1. Plant height (cm)*

Plant height was measured two times at 30 days interval such as 30, and 60 days after sowing (DAS). The height of the plant was measured by scale considering the distance from the soil surface to the tip of the randomly ten selected plants and mean value was calculated for each treatment.

### *3.11.2. Number of leaves plant$^{-1}$*

Number of leaves plant$^{-1}$was counted two times at 30 days interval such as 30 and 60 DAS of fenugreek plants. Mean values of data were calculated and recorded.

### *3.11.3. Number of primary branches plant$^{-1}$*

Number of branches was counted from randomly selected ten plants from each plot and mean values were calculated and recorded.

### *3.11.4. Plant spread (cm)*

At first the measurement was made in centimeter North-South (N-S) direction of the plant canopy of randomly selected ten plants at first flowering stage. Again, the measurement was made in centimeter East-west (E-W) direction of the plant canopy of randomly selected ten plants. Average plant spread (cm) was measured by adding those two values and dividing by two.

### *3.11.5. Number of pods plant$^{-1}$*

Pods of ten randomly selected plants of each replication were counted and then the average number of fruits for each plant was determined. It was done at final harvest.

### *3.11.6. Weight of seeds pod$^{-1}$ (mg)*

Seed weight pod$^{-1}$ (g) was measured by Electric Balance in gram (mg). Seeds from ten selected plants from each unit plot were collected and divided by ten to calculate weight of seeds per plant.

### *3.11.7. 1000 seed weight (g)*

1000 seed weight was measured by Electric Balance in gram (g). 1000 seed from each treatment were counted then weighed.

### *3.11.8. Weight of single pod (g)*

Pod weight was measured by Electric Precision Balance in gram (g). Ten randomly fruits from each of the treatment were weighted and then divided by ten to get single individual pod weight.

#### *3.11.9. Number of seeds pod$^{-1}$*

Ten pods of each of randomly selected 10 plants were considered and then seeds per pod were counted from all the pods and the average data were taken as number of seeds pod$^{-1}$.

#### *3.11.10. Weight of seeds plant$^{-1}$ (g)*

Seed weight pod$^{-1}$ was measured by Electric Balance in milligram (g). Seeds from each treatment were counted and then weighed.

#### *3.11.11. Weight of straw plot$^{-1}$ (g)*

After seed collection all plant of each unit plot were dried in the sun. Then total plants of each unit plot were weighed to get weight of straw plot$^{-1}$.

#### *3.11.12. Number of plant plot$^{-1}$ at harvest*

Number of plant was counted during final harvesting of fenugreek plant

#### *3.11.13. Seed yield plot$^{-1}$ (g)*

After maturity seeds of all plants except 10 selected plants were harvested and cleaned. Then seed was measured with electric balance in gram. Then this weight was added to seed weight of 10 selected plants to obtain seed yield plot$^{-1.}$

#### *3.11.14. Seed yield (kg ha$^{-1}$)*

Seed yield plot$^{-1}$ (g) was converted to per hectare yield (kg ha$^{-1}$).

### 3.12. Statistical analysis

The data in respect of growth and yield components were statistically analyzed to find out the significance of the experimental results. The means of all the treatments were calculated and the analysis of variance for each of the characters under study was performed by F test. The difference among the treatment means was evaluated by DMRT (Gomez and Gomez, 1984) at 5% level of probability.

## 4. Result and discussion

The result obtained with different levels of phosphorous (P), sulphur (S) and their combinations were presented and discussed in this chapter. Data on morphological parameters, yield contributing characters

and seed yield of fenugreek were in both tables and figures and analyses of variance and corresponding degrees of freedom had been shown in Appendices.

## 4.1. Plant height

The application of different phosphorous (P) and sulphur (S) levels had significant effects on fenugreek plant height at different days after sowing (DAS) (Table 1). The highest plant height (26.73 cm) was found when the field was fertilized with the dose of 40 kg $ha^{-1}$ of phosphorous and 10 kg $ha^{-1}$ of sulphur at 30 days after sowing (DAS). At 30 DAS, the second highest but identical plant height was observed as 25.89 cm with the application of 40 kg P $ha^{-1}$ and 20 kg S $ha^{-1}$, but the third highest plant height (25.35 cm) was found with the application of 30 kg P $ha^{-1}$ and zero (0) kg S $ha^{-1}$. The lowest plant height (23.19 cm) was observed from the control ($P_0S_0$) at 30 days after sowing.

The plant height increased with increasing the age of the plants. The highest plant height (32.47 cm) was obtained when the field was fertilized with the dose of 40 kg $ha^{-1}$ of phosphorus and 20 kg $ha^{-1}$ of sulphur at 60 days after sowing (DAS). The second nearest height was observed as 30.83 cm with the application of 40 kg P $ha^{-1}$ and 10 kg S $ha^{-1}$. But the third most plant height was found as 29.81 cm with the application dose of 30 kg P $ha^{-1}$ and 10 kg S $ha^{-1}$. The lowest plant height (26.67 cm) was observed from the application dose of zero (0) kg P $ha^{-1}$ and 10 kg S $ha^{-1}$, whereas the second lowest plant height 27.91cm was found from the control at 60 days after sowing. Application of 40 kg $P_2O_5$/ha gave significantly higher plant height at all the growth stages (Metha et al., 2012).

**A** **B**

**Figure 2.** Plant height at 30 (A) and 60 (B) days after sowing

**Table 1.** Combined effect of phosphorus and sulphur on the height of fenugreek plant at different days after sowing (DAS)

| Treatment | Plant height (cm) | |
|---|---|---|
| | 30 DAS | 60 DAS |
| $P_0S_0$ | 23.19 e | 27.91 de |
| $P_0S_1$ | 23.98 cde | 26.67 e |
| $P_0S_2$ | 23.72 de | 26.87 e |
| $P_1S_0$ | 24.05 cde | 27.77 de |
| $P_1S_1$ | 25.22 b | 28.24 cde |
| $P_1S_2$ | 24.75 bcd | 27.98 cde |
| $P_2S_0$ | 25.35 b | 29.35 bcd |
| $P_2S_1$ | 21.93 f | 29.81 bc |
| $P_2S_2$ | 25.07 bc | 27.12 e |
| $P_3S_0$ | 24.03 cde | 29.05 bcd |
| $P_3S_1$ | 26.73 a | 30.83 ab |
| $P_3S_2$ | 25.89 ab | 32.47 a |
| CV (%) | 8.07 | 7.79 |

Means with uncommon letter(s) are significantly different at 5% probability level by DMRT.
$P_0$ = 0.0 kg ha$^{-1}$ (control), $P_1$ = 20 kg ha$^{-1}$, $P_2$ = 30 kg ha$^{-1}$ and $P_3$ = 40 kg ha$^{-1}$; $S_0$ = 0.0 kg ha$^{-1}$ (control), $S_1$ = 10 kg ha$^{-1}$, $S_2$ = 20 kg ha$^{-1}$

## 4.2. Number of primary branches plant$^{-1}$

The maximum number of primary branches plant$^{-1}$ (4.60) was found from the application of fertilizer with the dose of 40 kg P ha$^{-1}$ and 20 kg S ha$^{-1}$ at 30 days after sowing (DAS) (Table 2). The identical nearest

number of primary branches plant$^{-1}$ (4.53) was observed from the application of 40 kg P ha$^{-1}$ and 10 kg ha$^{-1}$ of sulphur. The lowest primary branches plant$^{-1}$ (2.80) was observed from the application 0.0 kg P ha$^{-1}$ and 0.0 kg S ha$^{-1}$ at 30 DAS. Jat and Shaktawat (2001) and Nehara et al. (2006) stated that there was relation between the phosphorous and sulphur applications. Nehara et al. (2006) obtained the highest number of branches with increasing phosphorous ($P_2O_5$) levels up to 50 kg ha$^{-1}$ and sulphur levels 50 kg ha$^{-1}$. Jat and Shaktawat (2001) got the highest primary branches plant$^{-1}$ from the application of 80 kg $P_2O_5$ ha$^{-1}$. At 60 DAS, the maximum number of branches plant$^{-1}$ was observed (5.37) from the dose of 40 kg P ha$^{-1}$ and 20 kg S ha$^{-1}$. The nearest number of branches (4.47) was observed with the dose of 40 kg P ha$^{-1}$ and 10 kg S ha$^{-1}$ at 60 DAS. And the lowest branch number (3.00) was counted from the control.

**Table 2.** Combined effect of phosphorus and sulphur on number of primary branches plant$^{-1}$ at different days after sowing (DAS) and plant spread of fenugreek

| Treatment | Number of primary branches plant$^{-1}$ | | Plant spread at first flowering (cm) |
|---|---|---|---|
| | 30 DAS | 60 DAS | |
| $P_0S_0$ | 2.80 f | 3.00 h | 2.96 e |
| $P_0S_1$ | 3.87 bc | 3.00 h | 4.06 cd |
| $P_0S_2$ | 4.08 b | 4.06 d | 4.47 c |
| $P_1S_0$ | 3.07 ef | 3.47 f | 3.54 de |
| $P_1S_1$ | 3.47 cde | 4.27 c | 4.16 cd |
| $P_1S_2$ | 3.33 de | 3.73 e | 4.28 c |
| $P_2S_0$ | 3.13 ef | 3.53 f | 3.49 de |
| $P_2S_1$ | 3.67 bcd | 3.71e | 5.67 b |
| $P_2S_2$ | 3.73 bcd | 3.26 g | 2.96 e |
| $P_3S_0$ | 3.13 ef | 3.20 g | 3.95 cd |
| $P_3S_1$ | 4.53 a | 4.47 b | 6.74 a |
| $P_3S_2$ | 4.60 a | 5.73 a | 6.76 a |
| CV (%) | 9.87 | 8.92 | 9.75 |

Means with uncommon letter(s) are significantly different at 5% probability level by DMRT.
$P_0$ = 0.0 kg $ha^{-1}$ (control), $P_1$ = 20 kg $ha^{-1}$, $P_2$ = 30 kg $ha^{-1}$ and $P_3$ = 40 kg $ha^{-1}$; $S_0$ = 0.0 kg $ha^{-1}$ (control), $S_1$ = 10 kg $ha^{-1}$, $S_2$ = 20 kg $ha^{-1}$

### 4.3. Plant spread (cm) at first flowering

The maximum plant spread at first flowering (6.76 cm) was found from the application of fertilizer with the dose of 40 kg P $ha^{-1}$ and 20 kg S $ha^{-1}$ (Table 2). The second highest plant spread at first flowering (6.74 cm) was observed from the application of 30 kg P $ha^{-1}$ and 10 kg S $ha^{-1}$. But the third most plant spread (5.67 cm) was recorded from the application dose of 30 kg P $ha^{-1}$ and 10 kg S $ha^{-1}$. The nearest amount of plant spread (4.47 cm) was found from the control of phosphorus and with the dose of 20 kg S $ha^{-1}$. The lowest plant spread (2.96 cm) was observed from the application of fertilizer with the dose of 0.0 kg P $ha^{-1}$ and 0.0 kg S $ha^{-1}$.

**Figure 3.** Plant spread ($cm^2$) at first flowering

## 5. Conclusion

The highest plant height (26.73 cm) was found when the field was fertilized with the dose of 40 kg $ha^{-1}$ of phosphorous and 10 kg $ha^{-1}$ of sulphur at 30 days after sowing (DAS). At 30 DAS, the second highest but identical plant height was observed as 25.89 cm with the application of 40 kg P $ha^{-1}$ and 20 kg S $ha^{-1}$. The maximum number of primary branches $plant^{-1}$ (4.60) was found from the application of fertilizer with the dose of 40 kg P $ha^{-1}$ and 20 kg S $ha^{-1}$ at 30 days after sowing (DAS). The identical nearest number of primary branches $plant^{-1}$ (4.53) was observed from the application of 40 kg P $ha^{-1}$ and 10 kg $ha^{-1}$ of sulphur. The lowest primary branches $plant^{-1}$ (2.80) was observed from the application of 0.0 kg P $ha^{-1}$ and 0.0 kg S $ha^{-1}$ at 30 DAS. At 60 DAS, the maximum number of branches $plant^{-1}$ was observed (5.73) from the dose of 40 kg P $ha^{-1}$ and 20 kg S $ha^{-1}$. The nearest number of branches (4.47) was observed with the dose of 40 kg P $ha^{-1}$ and 10 kg S $ha^{-1}$ at 60 DAS. The maximum plant spread at first flowering (6.76 cm) was found from the

application of fertilizer with the dose of 40 kg P $ha^{-1}$ and 20 kg S $ha^{-1}$. The second highest plant spread at first flowering (6.74 cm) was observed from the application of 40 kg P $ha^{-1}$ and 10 kg S $ha^{-1}$. But the third most plant spread (5.67 cm) was recorded from the application dose of 30 kg P $ha^{-1}$ and 10 kg S $ha^{-1}$.

Based on the findings of the present study, the following conclusion might be drawn:

1- The combined application of 40 kg P $ha^{-1}$ and 20 kg S $ha^{-1}$ produced the maximum plant height at 60 days after sowing (DAS), primary branches $plant^{-1}$ both at 30 and 60 DAS which were identical with the combined application of 40 kg P $ha^{-1}$ and 10 kg S $ha^{-1}$.

2- Application of 40 kg P $ha^{-1}$ in combination with 10 kg S $ha^{-1}$ gave the maximum plant height at 30 DAS.

## 6. Recommendation

Application of phosphorous @ 40 kg $ha^{-1}$ in combination with sulphur @ 10 kg $ha^{-1}$ is suitable for fenugreek cultivation.

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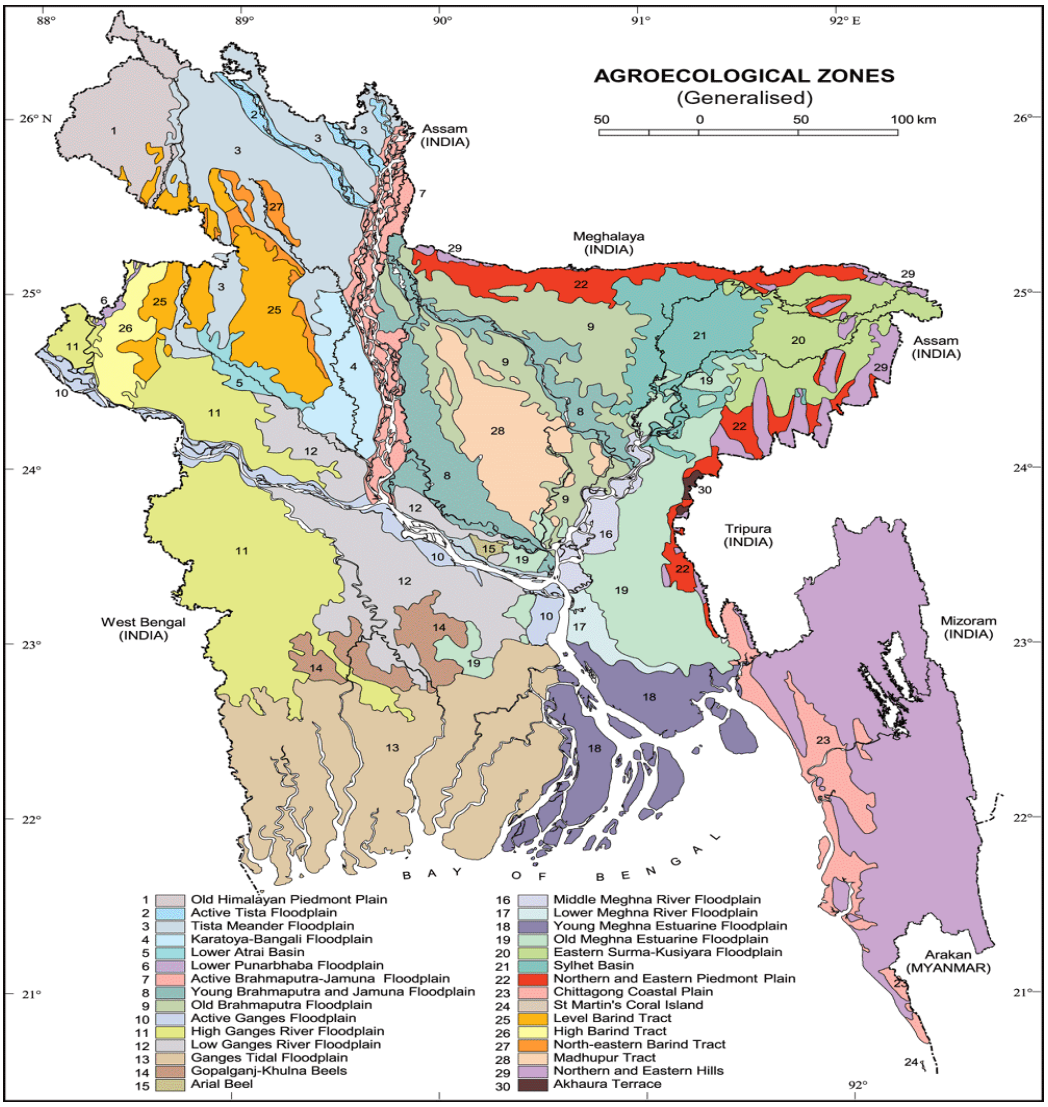
## APPENDICES

**Appendix I.** Experiment was conducted in Sher-e-Bangla Agricultural University, Dhaka (AEZ-28) on the map of Agro-ecological Zones of Bangladesh.



**Appendix II**. Soil analysis of the experimental field prior to Experimentation

**A. Morphological Characteristics**

| Morphological features | characteristics |
|---|---|
| Location | SAU Farm, Dhaka |
| AEZ | Modhupur Tract (28) |
| General Soil Type | Shallow red brown terrace soil |
| Land Type | Medium high land |
| Soil Series | Tejgaon |
| Topography | Fairly leveled |
| Flood Level | Above flood level |
| Drainage | Well drained |

**B. Mechanical analysis**

| Constituents | Percent |
|---|---|
| Sand | 27 |
| Silt | 43 |
| Clay | 30 |

**C. Chemical analysis**

| Soil properties | Amount |
|---|---|
| Soil pH | 5.8 |
| Organic carbon (%) | 0.45 |
| Total nitrogen (%) | 0.03 |
| Available P (ppm) | 20 |
| Exchangeable K (%) | 0.1 |
| Available S (ppm) | 45 |

*Source: Soil Resource Development Institute (SRDI)*

**Appendix III.** Monthly average air temperature, rainfall and relative humidity of the experimental site during the period from November to March 2016/2017

| Months | Air temperature (°C) | | Relative humidity (%) | Total rainfall (mm) |
|---|---|---|---|---|
| | Maximum | Minimum | | |
| November, 2016 | 31.6 | 21.4 | 68.2 | 33 |
| December, 2016 | 30.2 | 20 | 59 | 11 |
| January, 2017 | 29 | 12.8 | 46 | 09 |
| February, 2017 | 30.8 | 15.9 | 47 | 15 |
| March, 2017 | 33 | 17.9 | 48.6 | 42 |

*Source: Bangladesh Meteorological Department, Agargaon, Dhaka-1207*